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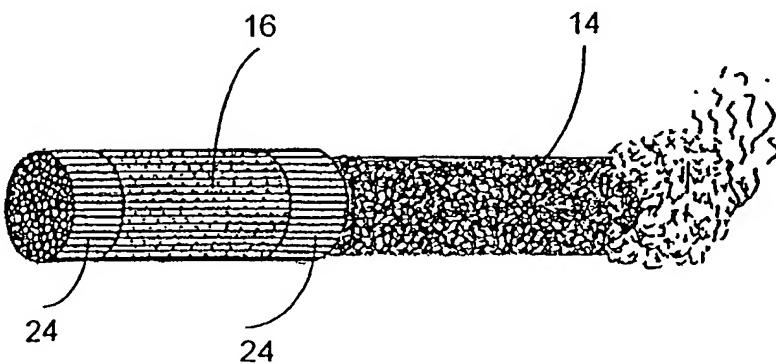
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(54) Title: A SMOKING ARTICLE INCLUDING A SELECTIVE CARBON MONOXIDE PUMP



(57) Abstract: A smoking article includes a tobacco column, a wrapper and a carbon monoxide pump. The pump includes an adsorbent for adsorbing carbon monoxide and may include a catalyst for oxidizing carbon monoxide to carbon dioxide and venting holes adjacent to the adsorbent. The carbon monoxide pump selectively diverts carbon monoxide from main stream combustion products, the catalyst at least partially oxidizes the carbon monoxide to carbon dioxide and the venting holes provide an alternative

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path for the diverted carbon monoxide and the oxidized carbon monoxide to check or reduce carbon monoxide inhalation by a smoker.

## A SMOKING ARTICLE INCLUDING A SELECTIVE CARBON MONOXIDE PUMP

### Background of the Invention

5 The present invention relates generally to smoking article and, more particularly, to a carbon monoxide pump for removing carbon monoxide from main stream smoke during the combustion of a smoking article.

10 Investigators have been trying now for about twenty years to find ways to lower the amount of carbon monoxide experienced by smokers when main stream smoke is inhaled. One of the issues with respect to carbon monoxide is the amount of carbon monoxide actually contained or produced by a smoking article. For example, an average amount of carbon monoxide produced by a smoking cigarette is as high as about 10-15 milligrams (mg). To adsorb this amount of carbon monoxide would require a very large amount of adsorbent for carbon monoxide if it was all intended to 15 be trapped by such an adsorbent. This is impractical and cost prohibited.

20 An alternative approach to adsorbing carbon monoxide is to oxidize it, for example, by the catalytic oxidation to carbon dioxide. A difficulty with this approach is that the temperature of the main stream smoke is substantially that of the environment. These low temperatures make it difficult to oxidize carbon monoxide to carbon dioxide even when using a catalyst.

Thus, there remains a need for a method and apparatus for carbon monoxide reduction in cigarette smoke.

### Summary of the Invention

25 The present invention fulfills this need by providing a smoking article including a tobacco column; a wrapper surrounding the tobacco column; and a carbon monoxide pump. The pump includes an adsorbent for adsorbing carbon monoxide and may include a catalyst for oxidizing carbon monoxide to carbon dioxide. In use, the carbon monoxide pump selectively diverts carbon monoxide from main stream 30 combustion products, the catalyst at least partially oxidizes the carbon monoxide to carbon dioxide and the venting holes provide an alternative path for the diverted carbon monoxide and the oxidized carbon monoxide to reduce inhalation by a

smoker. In a preferred embodiment, venting holes adjacent to the adsorbent facilitate the further diversion of carbon monoxide from main stream smoke

A preferred catalyst is a transition metal including rare earth metals and a platinum group metal. Preferred transition metals include at least one of copper, 5 cobalt, iron, silver, nickel, their alloys, their mixtures and combinations thereof, with silver being the most preferred. The transition metal may be elemental, an oxide, or combinations thereof.

In an embodiment, the CO pump includes at least one additional filter element, preferably cellulose acetate. A catalyst may be distributed through the at least one 10 additional filter element

In the vicinity of the adsorbent, the concentration of carbon monoxide is increased, thereby increasing the flux of carbon monoxide from the adsorbent. The adsorbing is momentary, preferably for between about 0.1 and about 10 seconds.

In a preferred embodiment, the adsorbent is a zeolite such as an oxide, more 15 preferably, at least one of silicon, aluminum, magnesium, their mixtures and their compounds. A dehydrated oxide, particularly of aluminum has been found to be effective. An amorphous oxide may also work. In a preferred embodiment, the adsorbent is a support for the catalyst.

Accordingly, one aspect of the present invention is to provide a smoking 20 article including a tobacco column; a wrapper surrounding the tobacco column; and a carbon monoxide pump including an adsorbent for adsorbing carbon monoxide, wherein the carbon monoxide pump is aligned with the tobacco column so as to selectively divert carbon monoxide from main stream combustion products prior to inhaling by a smoker.

Another aspect of the present invention is to provide a carbon monoxide pump 25 for use in a smoking article including a tobacco column and a wrapper surrounding the tobacco column. The carbon monoxide pump includes an adsorbent for adsorbing carbon monoxide, and a catalyst. When placed adjacent to the tobacco column, the carbon monoxide pump selectively diverts carbon monoxide from main stream combustion products by adsorbing carbon monoxide, and the catalyst at least partially 30 oxidizes the diverted carbon monoxide to carbon dioxide prior to being inhaled by a smoker.

Still another aspect of the present invention is to provide a smoking article including a tobacco column; a wrapper surrounding the tobacco column; and a carbon monoxide pump. The pump includes an adsorbent for adsorbing carbon monoxide; a catalyst for oxidizing carbon monoxide to carbon dioxide, and venting holes adjacent to the adsorbent. In use, the carbon monoxide pump selectively diverts carbon monoxide from main stream combustion products, the catalyst at least partially oxidizes the carbon monoxide to carbon dioxide, and the venting holes provide an alternative path for the diverted carbon monoxide and the oxidized carbon monoxide to reduce inhalation by a smoker.

10 The invention also provides a mouthpiece for a smoking article including a fitting to receive a smoking article, and a carbon monoxide pump including an adsorbent for adsorbing carbon monoxide, wherein the carbon monoxide pump is positioned with respect to the smoking article so as to selectively divert carbon monoxide from main stream combustion products prior to inhaling by a smoker.

15 These and other aspects of the present invention will become apparent to those skilled in the art after a reading of the following description of the preferred embodiment when considered with the drawings.

#### Brief Description of the Drawings

20 FIGURE 1A is a smoking article according to the present invention;  
FIGURE 1B is an exploded view of the smoking article of Figure 1A;  
FIGURE 2 is a schematic of a tobacco column adjacent to a selective carbon monoxide pump according to the present invention;  
FIGURE 3 is a block flow diagram for a carbon monoxide pump according to  
25 the present invention; and  
FIGURE 4 is a partial perspective view of a mouthpiece according to the invention.

#### Description of the Preferred Embodiments

30 Referring now to the drawings in general and Figure 1 in particular, it will be understood that the illustrations are for the purpose of describing a preferred embodiment of the invention and are not intended to limit the invention thereto. As

best seen in Figures 1A and 1B a smoking article includes a wrapper 12 surrounding a tobacco column 14 adjacent to carbon monoxide pump 16. Preferably, the pump 16 selects carbon monoxide for diversion from main stream smoke. A further feature of the embodiment shown in Figure 1 is the presence of venting holes 18. As best seen  
5 in Figure 1B, which is an exploded view of the smoking article in Figure 1A, the wrapper 12 surrounds tobacco column 14. As best seen in Figures 1B and 2, the selective carbon monoxide pump 16 may be placed adjacent to, but not necessary abutting the tobacco column 14. Typically it is aligned with the tobacco rod so that smoke from the tobacco combustion passes through the pump 16. Other paths that  
10 expose the smoke to the pump may be used.

Additionally, as seen in Figure 2, at least one additional filter element 24 may be included in the smoking article 10. Although Figure 2 depicts the selective carbon monoxide pump 16 between two additional filter elements 24, there may be a single additional filter element 24. In such case, the at least one filter element 24 may be at  
15 either between the tobacco column 14 and the selected carbon monoxide pump 16. Alternatively, the carbon monoxide pump 16 may be between the tobacco column 14 and the at least one additional filter element 24. The filter element 24 is typically of a conventional filter material such as cellulose acetate.

In operation, the selected carbon monoxide pump 16 diverts carbon monoxide  
20 from main stream smoke to, for example, side stream smoke. A block diagram of the pump's operation is seen in Figure 3. Starting at the top of Figure 3, after a smoking article 10 including the carbon monoxide pump 16 is lit, a smoker draws on the article from the filtered end. As the smoker draws on the smoking article 10, the combustion products are drawn through the carbon monoxide pump 16 for diverting carbon  
25 monoxide from the main stream smoke..

In an embodiment having a catalyst, the carbon monoxide diverted from the combustion products interacts with the catalyst and is oxidized to carbon dioxide. When venting holes 18 are placed proximate to the carbon monoxide pump, the carbon dioxide is expressed through the venting holes 18 and inherent pores in the  
30 wrapping paper around the carbon monoxide pump 16. The inclusion of venting holes 18 proximate to the carbon monoxide pump 16 and the inherent porosity provide a passage for the oxidized carbon monoxide, which is carbon dioxide, to be

expressed from smoking article. In embodiments having no venting holes 18, inherent pores within the paper provide a path for the expression of oxidized carbon monoxide. Carbon dioxide, generated from carbon monoxide, may also remain in the main stream smoke, providing no harm to the smoker.

5        In an alternative embodiment, having no catalyst, the carbon monoxide pump 16 includes an adsorbent material. In this embodiment, as the main stream smoke passes over the adsorbent material, carbon monoxide is adsorbed from the main stream smoke onto the adsorbent material. During the delay between the current puff and the successive puff, which may be called an inter-puff period, the concentration 10 of carbon monoxide increases in gas phase within the adsorbent material due to its desorption. The higher concentration of the carbon monoxide in the vicinity of the adsorbent material creates a driving force that increases the flux of carbon monoxide from the adsorbent material so that it exits holes 18 proximate to the carbon monoxide pump 16.

15      As best seen in Figure 3, the drawing, diversion and expression cycles continue during the consumption of the smoking article and in this manner, the amount of carbon monoxide inhaled by the smoker is substantially reduced.

20      The following examples provided to give a better understanding of the invention and its operation through a discussion of the synthesis, testing and characterization. The examples are in no way meant to limit the scope of the claimed invention.

25      Example 1.    Gas chromatographic analysis using a Model No. 6890, manufactured by Hewlett Packard, and an infrared CO sensor, manufactured by Filtrona, Inc., were used to determine the gas phase content of cigarette smoke under standard smoking conditions using a filling machine, manufactured by Filamatic, Inc., reconstructed to a smoking machine. As part of this analysis, the removal of CO from the gas was studied using an artificial mixture comprising helium with about 2% carbon monoxide by volume. About 1% by volume nitrogen was added to this mixture as an internal standard. Catalytic oxidation of CO was also studied using a 30 mixture of helium, about 2% CO by volume, and about 13% oxygen. The above concentrations were prepared to simulate the average characteristics of tobacco smoke.

During analysis, the gas mixture was passed through the an about 2 milliliter (ml) GC gas loop, manufactured by Hewlett Packard, at about atmospheric pressure. The adsorbent to be studied was loaded into a stainless steel tube reactor. Adsorption was then studied by injecting the content of the gas 5 loop into a pure helium flow of about 200 ml/min rate; the CO mixture with the carrier gas was then passed through the adsorbent in the reactor. The resultant gas was then passed to the GC for analysis. The reactor was maintained at about room temperature during these experiments. The reactor was also used to pre-treat solid adsorbent samples at elevated temperatures.

10        Aluminum oxide was tested for CO adsorption application because of its Lewis acidity; this property is known to promote CO chemisorption. The experimental results showed that fresh alumina is inactive in adsorption of CO at about room temperature. It is believed that the equilibration of the ambient atmosphere with the alumina surface blocks any CO active adsorption sites. For 15 example, water molecules from the ambient atmosphere may occupy the CO active adsorption sites.

20        Heating of alumina ( $\text{Al}_2\text{O}_3$ ) to about 300-350°C in air provided an improvement in CO. If water molecules occupy the CO active adsorption sites, a dehydration (e.g., desorption of water molecules) of the CO adsorption sites may explain the increased activity after heat treating. Applicants believe that the CO adsorption property of alumina may be enhanced by altering the surface structure of alumina by for example making it more irregular, as for example, in zeolites.

25        Example 2. Zeolites ranging in aperture size from about 3 to about 9 angstroms ( $\text{\AA}$ ) were applied in a study of CO adsorption from a pulsed gas. A fixed bed reactor, filled with zeolite, produced delays in the CO pulse; these delays resulted from a relatively weak adsorption. Size-selective dry molecular sieves created larger delay times when a 5 $\text{\AA}$  aperture size approximately matched the diameter of CO molecule.

30        It was determined that the high affinity of zeolites for water reduces the CO trapping activity of about 5 $\text{\AA}$  zeolite. An effective decrease in the zeolite pore sizes caused by the adsorption of water molecules appears to initiate this reduction. Experiments supported this idea, showing that a hydrated about 9 $\text{\AA}$

zeolite possessed substantially the same CO adsorption activity as that of an about 5Å dehydrated sample. Results also suggest that zeolites with a pore size of about 5Å or greater may be used as a starting material to develop a carbon monoxide pump that diverts CO from main stream smoke.

5       Example 3. An Ag<sub>2</sub>O/ about 5Å zeolite and an Ag<sub>2</sub>O/about 9Å 13X zeolite catalyst/adsorbents were prepared. About 5 grams (g) of silver nitrate were dissolved in about 15 ml of an about 10M NH<sub>4</sub>OH solution that was then combined with water for dilution to about 50 ml. About 20g of about 0.4 to about 0.8 millimeter (mm) beads of a zeolite were added and allowed to remain 10 overnight for a silver exchange. Each zeolite mixture was shaken frequently for about the first hour to remove evolved air. The catalyst was thoroughly washed with about 2L of water, dried for about 2 hours in air at about 60°C and overnight at about 150°C to decompose [Ag(NH<sub>3</sub>)<sub>2</sub>]NO<sub>3</sub>. After this treatment the resulting light-yellow catalyst was stored in a jar.

15       The removal of CO from a gas was studied using freshly prepared samples in the reactor and the gas mixtures described in Example 1. About 300 milligrams (mg) of each CO pump material were loaded in a filter. Experimental results showed reductions of CO in main stream smoke as high as about 50-60% by volume.

20       Example 4. Catalyst/adsorbent samples comprising Ag<sub>2</sub>O-on-about 13X zeolite (about 9Å) from Lancaster, and CP861E (about 7Å) and CBV5524G (about 5Å) from Zeolyst International were prepared substantially as described in Example 3. Atomic absorption analyses using a Spectr AA-100, manufactured by Varian, provided the concentrations of silver in the samples. These 25 concentrations are summarized in Table 1 and the corresponding CO removal activities are summarized in Table 2.

Table 1: Concentration of Silver in Zeolite-Supported Catalysts/Adsorbents from AA Analysis Data.

Sample	Support	% silver
1	13X zeolite (Lancaster)	8.5
2	CBV5524G (NN 2..4 are from Zeolyst)	4.0
3	CP861E (exchanged/milled/sieved)	10.0
4	CP861E (milled/sieved/exchanged)	7.8

Also, zeolites containing silver showed high activity in the catalytic oxidation of CO at higher temperatures. A study of the kinetics of oxidation of CO on silver oxide and a partially reduced silver catalyst revealed that silver catalysts reduced at about 110-150°C were more active in oxidation of CO, and 5 may provide about 70% removal of CO from main stream smoke. However, applicants believe that an excessively active catalyst may provide poor CO removal because of its irreversible deactivation by of other combustion products (see for example sample 2 in Table 2 having a small zeolite pore size).

Table 2: CO Removal from Main stream Smoke by Modified Cigarette Filters, Containing Ag/zeolite CBV5524G (about 5Å)

Sample	Filter and Cigarette	% CO removed
1	Ag <sub>2</sub> O/Z in vented filter	about 60
2	#1, reduced CO at about 120°C	about 0
3	Ag <sub>2</sub> O/Z in non-vented filter	about 22
4	Ag <sub>2</sub> O/Z in tobacco	about 37

10 Note: Sample 4 contained approximately the same amount of Ag/zeolite adsorbent, but distributed in the tobacco.

The results summarized in Table 3 indicate that a similar treatment of Ag/zeolite at about 120°C in a reducing gas containing CO may led to an increase 15 in CO removal from about 50 to about 71%, when zeolite as large as about 9Å was used. Even after about 3 hours in humid room air, CO removal activity was not decrease and was measured as at about 81%. These results were confirmed when zeolite CP861E with an aperture size of about 7Å was used.

Corresponding data are summarized in Table 5.

20 As indicated by the results summarized in Table 3, a higher reduction temperature of about 150°C does not further improve the performance of a catalyst compared to the sample, heat-treated at 120°C. These results imply that a partial reduction of silver in a Ag/zeolite adsorbent/catalyst may be a useful treatment, positively affecting the CO removal effectiveness. CO removal 25 conditions however, must be carefully predetermined and controlled to avoid an over-reduction of silver.

As the results summarized in Table 2 shows, an about 5Å zeolite, used in a non-vented cigarette, provides a lower degree of CO removal of about 22%.

Also, the results indicate that the performance of this CO pump material may be slightly improved when Ag/zeolite material is mixed with tobacco rather than placed in a filter. Applicants believe this occurs since CO concentrated on an adsorbent during a puff is diffused out of the cigarette between puffs. Diffusion 5 of CO through the porous cigarette paper in the case of an adsorbent mixed into the tobacco may be faster than that through a filter paper of a vented CO pump.

The results summarized in Table 6 indicate that venting holes in the CO pump, as well as a thinner paper, facilitate the removal of CO from main stream smoke (e.g., an about 7Å zeolite, modified with silver, was used in a vented and a 10 non-vented CO pump). The effectiveness of CO removal was found to be about 73% and about 27% respectively.

The results of Table 3 show that an Ag/zeolite 13X-based materials did not completely lose its activity after about one cigarette smoked. These materials retained enough activity to provide about 30% CO removal from a second 15 cigarette. This may allow less material in a CO pump.

Table 3. CO Removal from Main stream Smoke by Modified Vented Cigarette Filters Containing Ag/zeolite 13X (about 9Å).

Sample	Filter	%CO removed
5	Ag <sub>2</sub> O/Z	about 50
6	#5, reduced CO at 120°C	about 71
7	#6 oxidized 3 hrs in air at room T	about 81
8	2 <sup>nd</sup> run of #7 with a new tobacco rod	about 32
9	#5, reduced CO at 150°C	about 55
10	2 <sup>nd</sup> run of #9 with a new tobacco rod	about 30

Table 4. CO Removal from Main stream Smoke by Modified Vented Cigarette Filters Containing (Ag+Pd)/zeolite 13X.

Sample	Filter	%CO removed
11	(Ag <sub>2</sub> O+Pd)/Z	about 50
12	#11, reduced CO at 120°C	about 75

Table 5. CO Removal from Main stream Smoke by  
Modified Vented Cigarette Filters  
Containing Ag/zeolite CP861E (about 7Å).

Sample	Filter	%CO removed
13	Ag <sub>2</sub> O/Z	about 42
14	#13, reduced CO at 120°C	about 56
15	#14, oxidized 5 hrs in air at room T	about 37

Note: Zeolite was modified, milled and sieved to about 40-60 mesh.

Table 6. CO Removal from Main stream Smoke by  
Modified Cigarette Filters  
Containing Ag/zeolite CP861.

Sample	Filter and Cigarette	%CO removed
16	Ag <sub>2</sub> O/Z in vented filter	about 73
17	#16, kept in cigarette for 2 hrs	about 48
18	#16, kept in cigarette for 1 day	about 45
19	#16, kept in cigarette for 2 days	about 26
20	#16, kept in cigarette for 3 days	about 22
21	#16, kept in cigarette for 10 days	about 50
22	Ag <sub>2</sub> O/Z in non-vented filter	about 27
23	#22, kept in cigarette for 0.5 hr	about 9

Note: Zeolite was milled, sieved 40-60 mesh and modified with Ag compound.

5        A feature of adsorbent preparation appears evident from data summarized  
in Tables 5 and 6. Sample 13 in Table 5 was prepared beginning with a silver  
water phase exchange procedure done to whole zeolite grains of about 2x6 mm  
size. After silver deposition the adsorbent was milled, sieved and packed in a  
filter. The effectiveness of this filter was about 42%; this effectiveness varied  
10 slightly from both an about 120°C reduction material and a long-term storage  
material.

Sample 16 in Table 6, was made starting with a milled and sieved CP861  
zeolite. Removal of CO by this material exceeded about 70%; its activity  
remained significant, although reduced, even after about 10 days at about room  
15 temperature in a vented CO pump. This result suggests that it may be preferred to  
a shape and sieve a zeolite prior to silver incorporation.

Example 5. Nickel oxide particles, modified with the rare-earth element  
dysprosium, were embedded into large-pore molecular sieves. These materials  
readily adsorb substantially all of the GC-detected, gas-phase organic molecules

except light hydrocarbons. The filtering properties of the adsorbent appeared to be similar to that of activated carbon. The Ni/Dy/zeolite system also demonstrated significant carbon monoxide adsorption activity.

5       About 10g of nickel acetate  $\text{Ni}(\text{CH}_3\text{HOO})_2 \cdot 4\text{H}_2\text{O}$ , from the Fisher Company, dissolved in 100 ml water, were mixed with about 30g zeolite CBV300-X16 from the Zeolite International Company. The zeolites were used as about 1x4 mm extruded granules. The mixture was retained at about room temperature for about 5 days to facilitate nickel ion exchange. The solution was then decanted and the zeolites were thoroughly washed with cold water.

10       About 3g of dysprosium chloride  $\text{DyCl}_3$  (grade REO), from Strem Chemicals, were dissolved in about 50 ml water and mixed with the solid material. The mixture was retained at about room temperature for about 5 additional days to exchange  $\text{Dy}^{3+}$  ions into the matrix. The solution was decanted. The solid material was washed with plenty of water, dried at about 15       50°C for about 2 days and annealed at about 350°C for about 2 days in air. The catalyst was stored in air as about 1x4 mm granules. Before conducting experiments, the sample was milled and about 40-60 mesh size particles were sieved off to be used in a CO pump.

20       About 500 mg of the catalyst were packed adjacent to tobacco in non-vented and vented research cigarettes. About 70% CO removal from main stream smoke was obtained in both cases. Also, GC analysis of the filtered tobacco smoke showed about 90% removal of acetaldehyde, acrolein and other functional derivatives, as well as unsaturated hydrocarbons. The adsorbent behaved essentially like an activated carbon with respect to these compounds (e.g., low 25       selectivity).

Example 6. Zeolite samples impregnated with copper and palladium ions were similarly prepared using their corresponding chlorides. Palladium salt was dissolved in aqueous HCl so that the  $\text{H}_2\text{PdCl}_4$  complex was used in place of the ammoniacal complex.

30       Copper- and palladium-containing zeolite of about 5 Å showed minor CO activity at about room temperature. Applicants believe that the high temperature activity and sensitivity to poisons (both known characteristics of copper and

palladium compounds) explain the results.

Example 7. Three samples were formed by distributing hydrochloric acid-doped polyaniline in both about 3Å and about 9Å zeolite samples, and on the surface of a cellulose/acetyl cellulosic cigarette filter. About 5g of the 5 corresponding zeolite or the cellulose acetate filters, taken from research cigarettes, were placed in about 300 ml solution of 5g aniline in an about 1M aqueous HCl. This suspension was mixed for about 20 hrs at about room temperature for aniline adsorption on carbon. The resulting solids were filtered and washed with about 500 ml water and about 100 ml of an about 1M HCl 10 solution. The supported aniline was suspended in about 300 ml of an about 1M HCl solution that was then cooled on ice.

About 11g of ammonium persulfate (about 98% pure) were dissolved in about 200 ml of an about 1M HCl solution. The solution was cooled on ice and slowly added to the suspension, while maintaining the temperature below about 15 10°C under a vigorous magnetic stirring. The temperature was allowed to self-equilibrate to about room temperature in about 2 hrs and stirring was continued for about another 20 hrs.

The resulting solids were filtered and washed with about 1L water on a filter and suspended in about 300 ml of an about 1M NH<sub>4</sub>OH solution under 20 mixing for about another 20 hrs. The supported polymers were washed with about 1L of water on a filter. The solid materials were suspended in about 300 ml of an about 1M HCl solution under mixing for about another 20 hrs. The final products, the HCl-doped supported polymers, were thoroughly washed in about 2L of water, filtered, dried in air at about room temperature for about 24 hrs and 25 stored.

Polyaniline embedded into about 3Å and about 9Å zeolite matrices showed very low CO adsorption activity. However, the same polymer supported on a cellulose/cellulose acetate cigarette filter adsorbed CO from the first cigarette puff. The following puffs remained unchanged because of the low 30 adsorptive, irreversible capacity of polyaniline.

The invention can also be carried out by providing a mouthpiece for a smoking article (such as a cigarette or cigar) to which the smoking article is attached

when smoked. If the pumping capacity of the mouthpiece is great enough, it may be reused with multiple smoking articles. The mouthpiece can be configured in numerous shapes and sizes as desired, but an example is seen in Figure 4. The mouthpiece M includes a fitting 22 to receive a smoking article C, and a carbon monoxide pump 24 including an adsorbent 116 for adsorbing carbon monoxide, wherein the carbon monoxide pump is positioned with respect to the smoking article C so as to selectively divert carbon monoxide from main stream combustion products prior to inhaling by a smoker. Vents 20, 118 can be provided like the vents 18 mentioned above. If desired, portions of the mouthpiece M may include a conventional filter material 120, such as cellulose acetate or other filter material.

Certain modifications and improvements will occur to those skilled in the art upon a reading of the foregoing description. By way of example, CO removal may be attempted by changing the smolder of a tobacco column, which in turn changes the chemical makeup of the main stream smoke. Even with changing the smolder of the tobacco column, the present invention may be effective. It should be understood that all such modifications and improvements have been deleted herein for the sake of conciseness and readability but are properly within the scope of the following claims.

We Claim:

1. A smoking article including  
a tobacco column;  
a wrapper surrounding the tobacco column; and  
5 a carbon monoxide pump including an adsorbent for adsorbing carbon monoxide, wherein the carbon monoxide pump is positioned with respect to the tobacco column so as to selectively divert carbon monoxide from main stream combustion products prior to inhaling by a smoker.
- 10 2. The smoking article according to Claim 1, further including venting holes adjacent to the carbon monoxide pump.
- 15 3. The smoking article according to Claim 2, wherein the venting holes facilitate the further diversion of carbon monoxide from main stream smoke.
- 20 4. A carbon monoxide pump for use in a smoking article including a tobacco column and a wrapper surrounding the tobacco column, the carbon monoxide pump including:  
an adsorbent for adsorbing carbon monoxide; and  
a catalyst,  
wherein when placed adjacent to the tobacco column, the carbon monoxide pump selectively diverts carbon monoxide from main stream combustion products prior by adsorbing carbon monoxide and the catalyst at least partially oxidizes the diverted carbon monoxide to carbon dioxide prior  
25 to being inhaled by a smoker.
- 30 5. The carbon monoxide pump according to Claim 4, wherein the catalyst is at least one of a transition metal, an oxide of a transition metal, and a transition metal and an oxide of a transition metal.
6. The carbon monoxide pump according to Claim 5, wherein the transition metal is a rare earth metal.

7. The carbon monoxide pump according to Claim 5, wherein the transition metal is a platinum group metal.

5 8. The carbon monoxide pump according to Claim 5, wherein the transition metal is at least one of copper, cobalt, iron, silver, nickel, their alloys, their mixtures and combinations thereof.

9. The carbon monoxide pump according to Claim 4, further including at 10 least one additional filter element.

10. The carbon monoxide pump according to Claim 9, wherein the additional filter element is cellulose acetate.

15 11. The carbon monoxide pump according to Claim 9, wherein at least a portion of the catalyst is distributed through the additional filter element.

12. The carbon monoxide pump according to Claim 4, wherein in the vicinity of the adsorbent the concentration of carbon monoxide is increased thereby 20 increasing the flux of carbon monoxide from the adsorbent.

13. The carbon monoxide pump according to Claim 4, wherein the adsorbing is momentary.

25 14. The carbon monoxide pump according to Claim 13, wherein the adsorbing is between about 0.1 and about 10 seconds.

15. The carbon monoxide pump according to Claim 4, wherein the adsorbent is a zeolite.

30

16. The carbon monoxide pump according to Claim 4, wherein the adsorbent is an oxide.

17. The carbon monoxide pump according to Claim 16, wherein the oxide is an oxide of at least one of silicone, aluminum, magnesium, there mixtures and there compounds.

5 18. The carbon monoxide pump according to Claim 17, wherein the oxide is a dehydrated oxide.

19. The carbon monoxide pump according to Claim 18, wherein the dehydrated oxide is an oxide of aluminum.

10

20. The carbon monoxide pump according to Claim 16, wherein the oxide is amorphous.

15 21. The carbon monoxide pump according to Claim 12, wherein the adsorbent is a support for the catalyst.

22. A smoking article including:  
a tobacco column;  
a wrapper surrounding the tobacco column; and  
20 a carbon monoxide pump including:  
an adsorbent for adsorbing carbon monoxide;  
a catalyst for oxidizing carbon monoxide to carbon dioxide, and  
venting holes adjacent to the adsorbent,  
wherein the carbon monoxide pump selectively diverts carbon  
25 monoxide from main stream combustion products, the catalyst at least  
partially oxidizes the carbon monoxide to carbon dioxide and the venting  
holes provide an alternative path for the diverted carbon monoxide and the  
oxidized carbon monoxide to check inhalation by a smoker.

30 23. The smoking article according to Claim 21, wherein the venting holes facilitate the further diversion of carbon monoxide from main stream smoke.

24. The smoking article according to Claim 21, wherein the catalyst is at least one of a transition metal, an oxide of a transition metal, and a transition metal and an oxide of a transition metal.

5 25. The smoking article according to Claim 24, wherein the transition metal is a rare earth metal.

26. The smoking article according to Claim 24, wherein the transition metal is a platinum group metal.

10

27. The smoking article according to Claim 24, wherein the transition metal is at least one of copper, cobalt, iron, silver, nickel, their alloys, their mixtures and combinations thereof.

15

28. The smoking article according to Claim 21, further including at least one additional filter element.

29. The smoking article according to Claim 28, wherein the additional filter element is cellulose acetate.

20

30. The smoking article according to Claim 28, wherein at least a portion of the catalyst is distributed through the additional filter element.

25

31. The smoking article according to Claim 21, wherein in the vicinity of the adsorbent the concentration of carbon monoxide is increased thereby increasing the flux of carbon monoxide from the adsorbent.

32. The smoking article according to Claim 21, wherein the adsorbing is momentary.

30

33. The smoking article according to Claim 32, wherein the adsorbing is between about 0.1 and about 10 seconds.

34. The smoking article according to Claim 21, wherein the adsorbent is a zeolite.

35. The smoking article according to Claim 21, wherein the adsorbent is an 5 oxide.

36. The smoking article according to Claim 35, wherein the oxide is an oxide of at least one of silicon, aluminum, magnesium, there mixtures and there compounds.

10

37. The smoking article according to Claim 36, wherein the oxide is a dehydrated oxide.

15

38. The smoking article according to Claim 37, wherein the dehydrated oxide is an oxide of aluminum.

39. The smoking article according to Claim 35, wherein the oxide is amorphous.

20

40. The smoking article according to Claim 31, wherein the adsorbent is a support for the catalyst.

25

41. A method for pumping carbon monoxide from the main stream smoke of a smoking article including a tobacco column a wrapper surrounding the tobacco column, said method comprising:

positioning a carbon monoxide pump including an adsorbent for adsorbing carbon monoxide, with respect to the tobacco column so as to selectively divert carbon monoxide from main stream combustion products prior to inhaling by a smoker.

30

42. A method for pumping carbon monoxide from the main stream smoke of a smoking article including a tobacco column a wrapper surrounding the tobacco column, said method comprising the steps of:

providing a carbon monoxide pump including:

5 an adsorbent for adsorbing carbon monoxide; and  
a catalyst,

wherein when placed adjacent to the tobacco column, the carbon monoxide pump selectively diverts carbon monoxide from main stream combustion products prior by adsorbing carbon monoxide and the catalyst at least partially oxidizes the diverted carbon monoxide to carbon dioxide prior to being inhaled by a smoker.

10 catalyst at least partially oxidizes the diverted carbon monoxide to carbon dioxide prior to being inhaled by a smoker.

43. A method for pumping carbon monoxide from the main stream smoke of a smoking article including a tobacco column a wrapper surrounding the tobacco column, said method comprising the steps of:

providing a carbon monoxide pump including:

an adsorbent for adsorbing carbon monoxide;

a catalyst for oxidizing carbon monoxide to carbon dioxide, and venting holes adjacent to the adsorbent,

20 wherein the carbon monoxide pump selectively diverts carbon monoxide from main stream combustion products, the catalyst at least partially oxidizes the carbon monoxide to carbon dioxide and the venting holes provide an alternative path for the diverted carbon monoxide and the oxidized carbon monoxide to check inhalation by a smoker.

25

44. A method for reducing carbon monoxide in main stream smoke of a smoking article that has a tobacco column comprising:

positioning a carbon monoxide pump in the path of the main stream smoke;

30 combusting the tobacco in the tobacco column;

drawing smoke from the combusting tobacco past the carbon monoxide pump;

adsorbing carbon monoxide from the main stream smoke onto an adsorbent;

catalytically oxidizing carbon monoxide to carbon dioxide at the adsorbent; and

5 expressing carbon dioxide through venting holes adjacent to the adsorbent.

45. A method for reducing carbon monoxide in main stream smoke of a smoking article that has a tobacco column comprising:

10 positioning a carbon monoxide pump in the path of the main stream smoke;

combusting the tobacco in the tobacco column;

drawing smoke from the combusting tobacco past the carbon monoxide pump;

15 adsorbing carbon monoxide from the main stream smoke onto an adsorbent;

releasing the carbon monoxide from the adsorbent and expressing carbon monoxide through venting holes adjacent to the adsorbent.

20 46. A mouthpiece for a smoking article comprising:

a fitting to receive a smoking article, and

a carbon monoxide pump including an adsorbent for adsorbing carbon monoxide, wherein the carbon monoxide pump is positioned with respect to the smoking article so as to selectively divert carbon monoxide from main stream combustion products prior to inhaling by a smoker.

47. A mouthpiece for a smoking article comprising:  
a fitting to receive a smoking article, and  
a carbon monoxide pump including:  
5 an adsorbent for adsorbing carbon monoxide;  
a catalyst for oxidizing carbon monoxide to carbon dioxide, and  
venting holes adjacent to the adsorbent,  
wherein the carbon monoxide pump selectively diverts carbon  
monoxide from main stream combustion products, the catalyst at least  
10 partially oxidizes the carbon monoxide to carbon dioxide and the venting  
holes provide an alternative path for the diverted carbon monoxide and the  
oxidized carbon monoxide to check inhalation by a smoker.

15

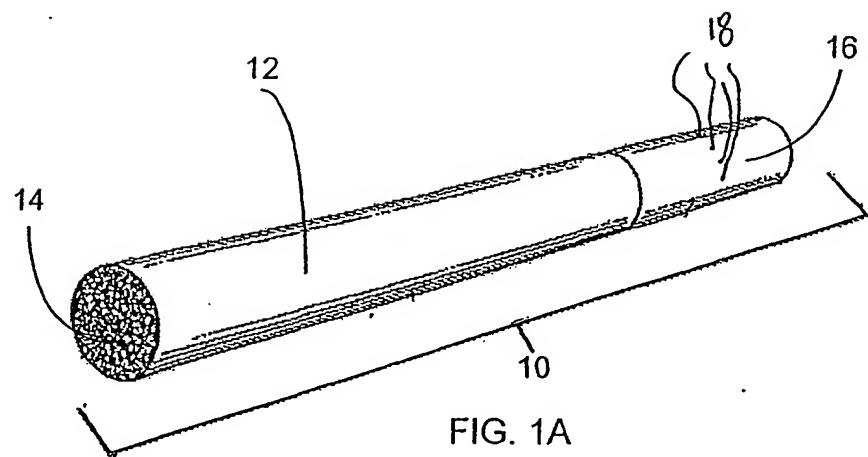


FIG. 1A

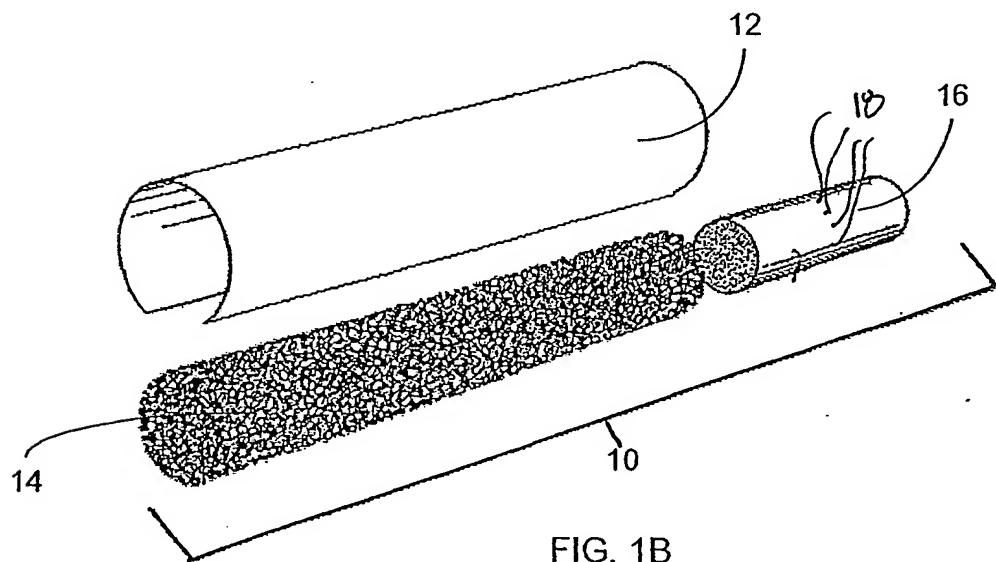


FIG. 1B

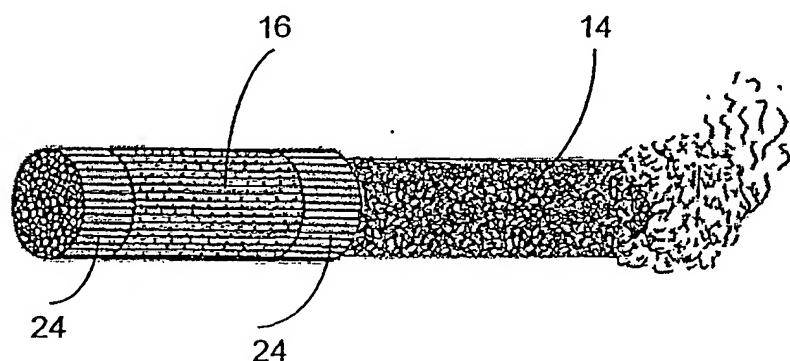


FIG. 2

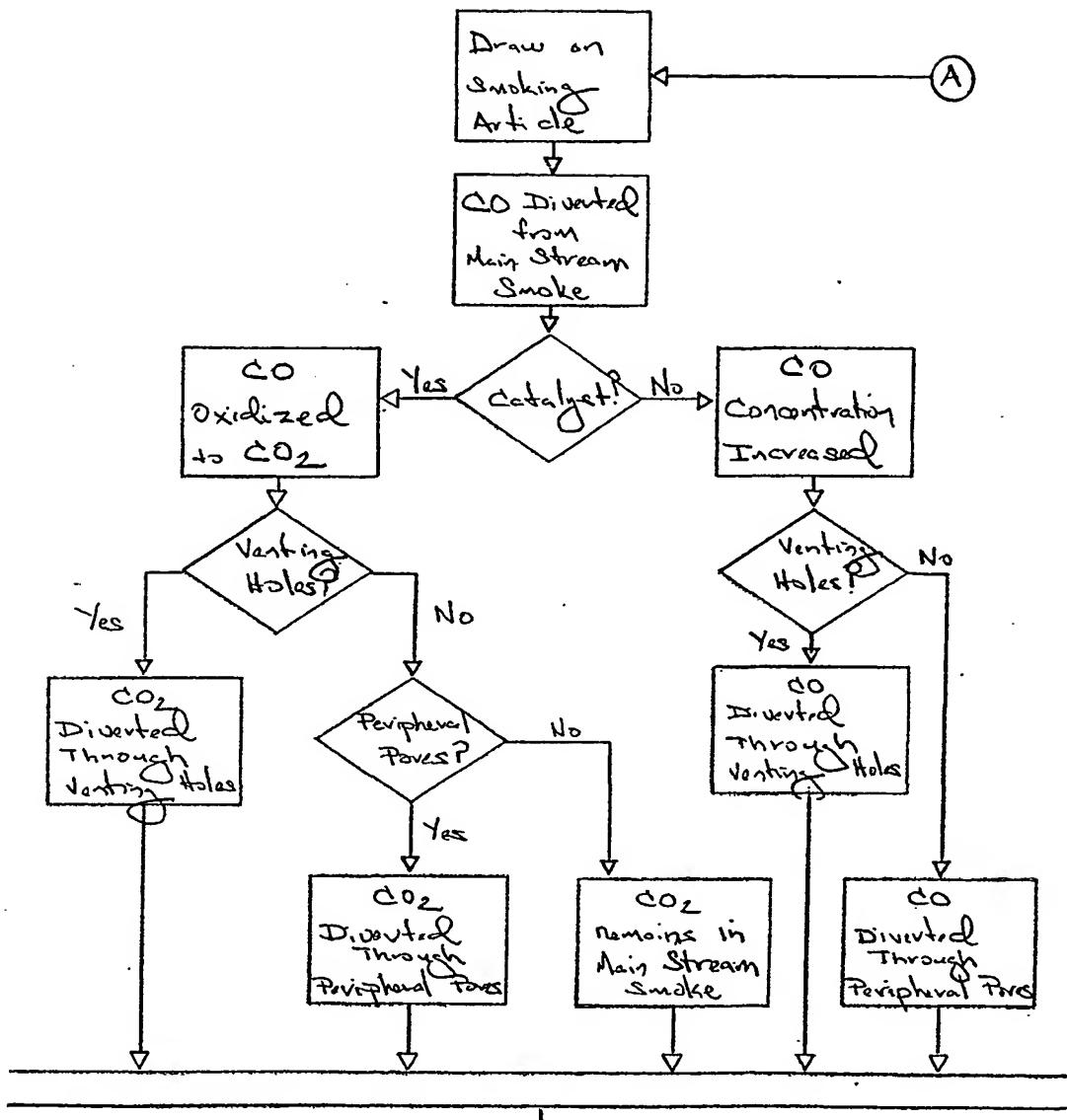
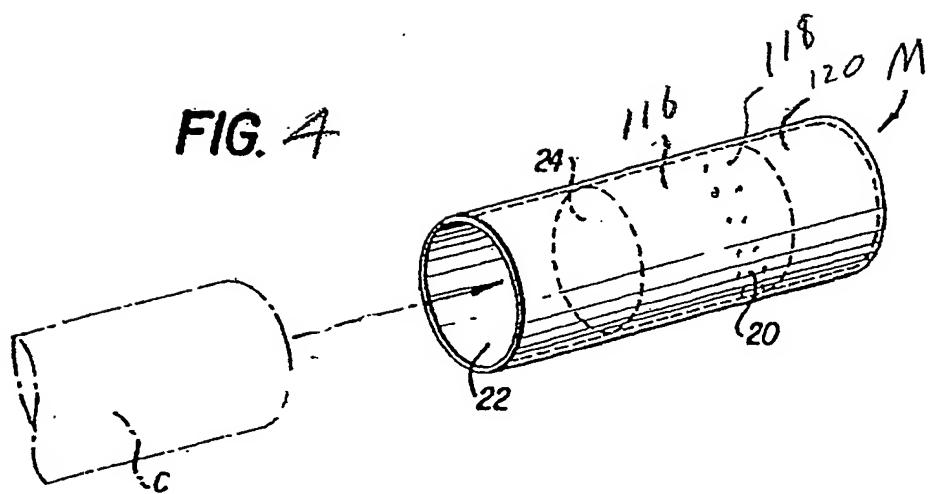


Fig 3

FIG. 4



**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/US01/45783

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(7) : A24D 3/00,3/06  
US CL : 131/331

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 131/331,342,194,273,247

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,317,460 (Dale et al) 2 March 1982 (02.03.82), Columns 4-6	1-3
Y		4-40, 46,47
Y	US 4,301,816 (Wahle et al) 24 Nov. 1981 (24.11.1981), Column 1 ,lines 35-40.	4-40, 46,47

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

14 February 2002 (14.02.2002)

Date of mailing of the international search report

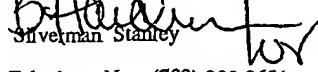
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**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/US01/45783

**Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)**

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claim Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claim Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claim Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:  
Please See Continuation Sheet

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-40 and 46-47

Remark on Protest

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.

**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/US01/45783

**BOX II. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING**

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s) 1-40 and 46-47 drawn to smoking article.

Group II, claim(s) 41-45, drawn to method of removing carbon monoxide.

The inventions listed as Groups I and II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The "special technical feature" of claim 1 and 41 is a carbon monoxide pump for absorbing carbon monoxide which is shown by Dale et al (US 4317460) to lack novelty or inventive step and does not make a contribution over the prior art.